



MDA Current Approach: Technically Based Opinion Mapped to Cost Growth History

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December 3, 2002



History



- Schedule/Technical (S/T) Risk mapping study performed 1994
- Cost Estimating (CE) Risk mapping performed 1998
- Methodology used by MDA since 1989
 - Variants of same methodology are used by AFCAA, NAVAIR, Intel Community, and others



Definitions (MDA)



- Cost Risk = Cost Estimating Risk + Schedule/Technical Risk + Requirements Risk + Threat Risk
 - Cost Estimating Risk: Risk due to cost estimating errors, and the statistical uncertainty in the estimate
 - Schedule/Technical Risk: Risk due to difficulty or inability to conquer problems posed by the intended design
 - Requirements Risk: Risk due to an as-yet-unseen design shift
 - Due to the inability of the intended design to perform the (unchanged) intended mission
 - The solution was inadequate
 - Threat Risk: Risk due to as-yet-unrevealed threat shift
 - We didn't understand the problem



MDA Cost Risk Assessment Approach

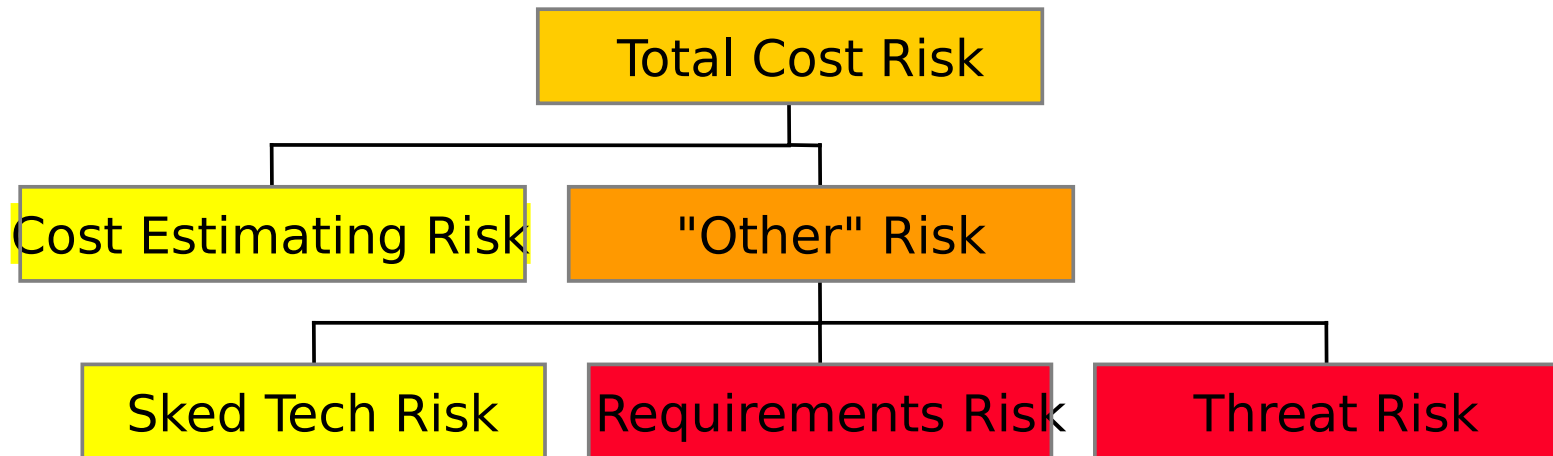


- Determine a mean and standard deviation for a normally distributed cost estimating risk distribution for each WBS element
- Determine a mean, high, and low endpoint for a symmetrical triangular schedule/technical risk distribution for each WBS element
- Combine these risk distributions and the point estimate using a Monte Carlo simulation
 - Produces an expected outcome, including risk, for each WBS element for each phase of the cost estimate



Risk Categories

As Estimated in the MDA Model



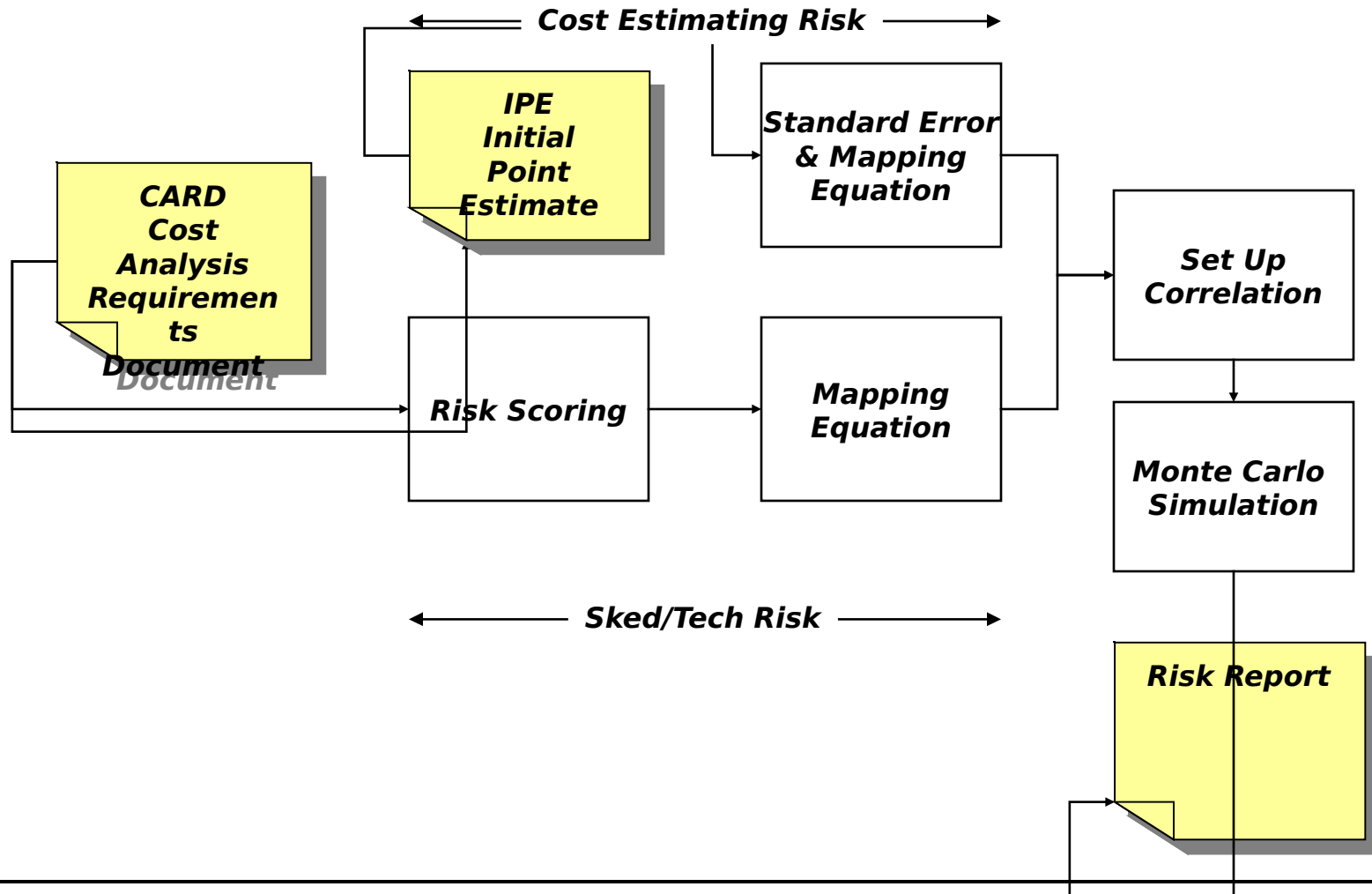
Scored

Not Scored

Our cost growth factors include all historic growth, Schedule/Technical score serves as a proxy for all other risk besides CE

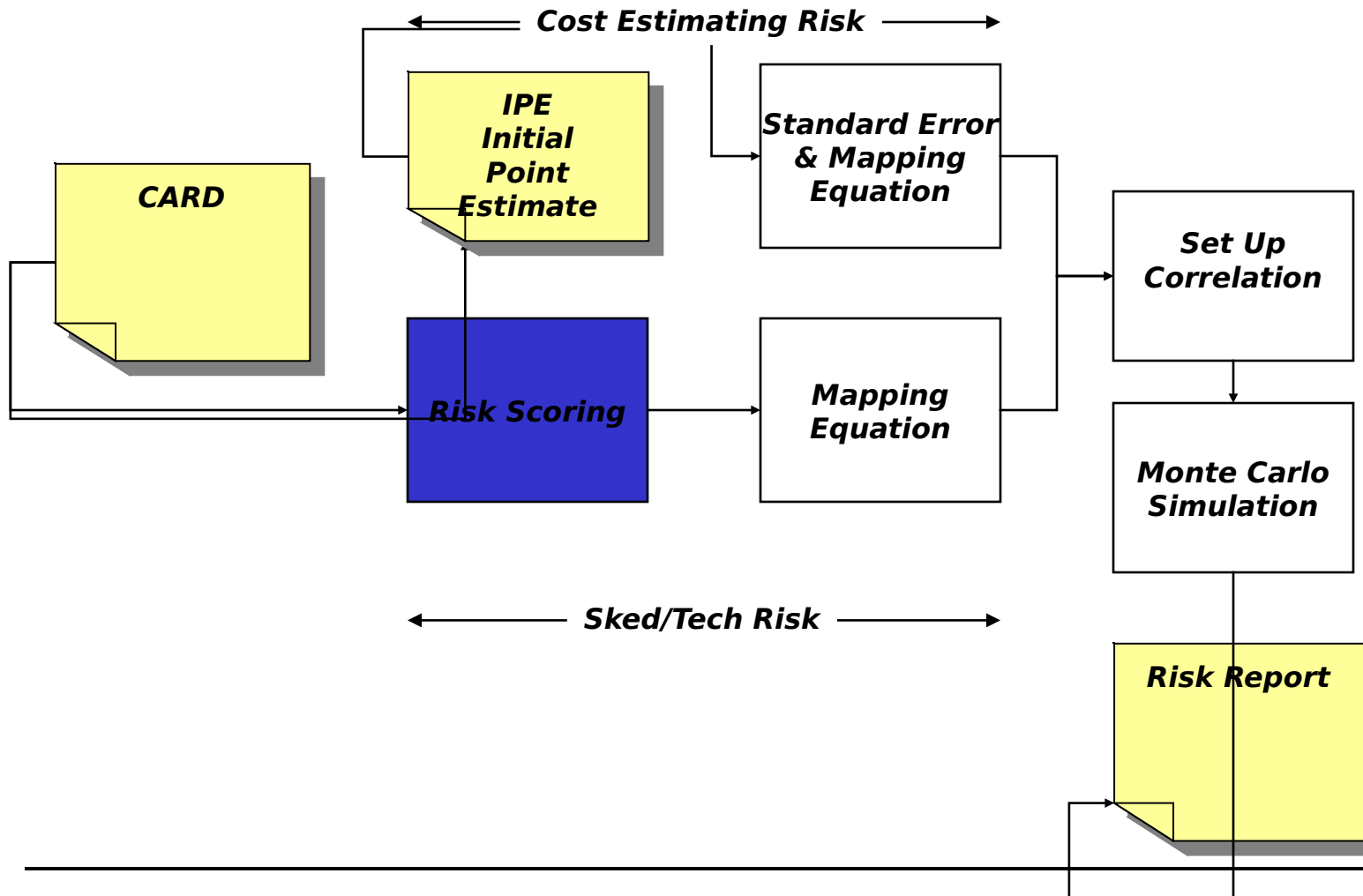


The MDA Cost Risk Process





The MDA Cost Risk Process





Schedule/Technical Risk Assessment



- The first step is risk scoring
 - Every WBS element that isn't a roll up will derive S/T Risk one of two ways
 - independently through risk scoring using a scoring matrix and mapping equation
 - dependently through correlation with another element
- Next we will discuss risk scoring using the scoring matrices



S/T Risk Scoring



- Find qualified scorers and train them
 - Provide them scoring matrices with specific WBS elements identified for them to score
 - Currently three different matrices:
 - Hardware
 - Software
 - Integration Assembly and Test (IA&T)
 - Each matrix is broken down into categories designed to reflect the risk drivers for the element in question
- Technical experts score each of the matrix categories from 0 (no risk) to 10 (high risk)
- Each category can be weighted depending on the relevancy of the category



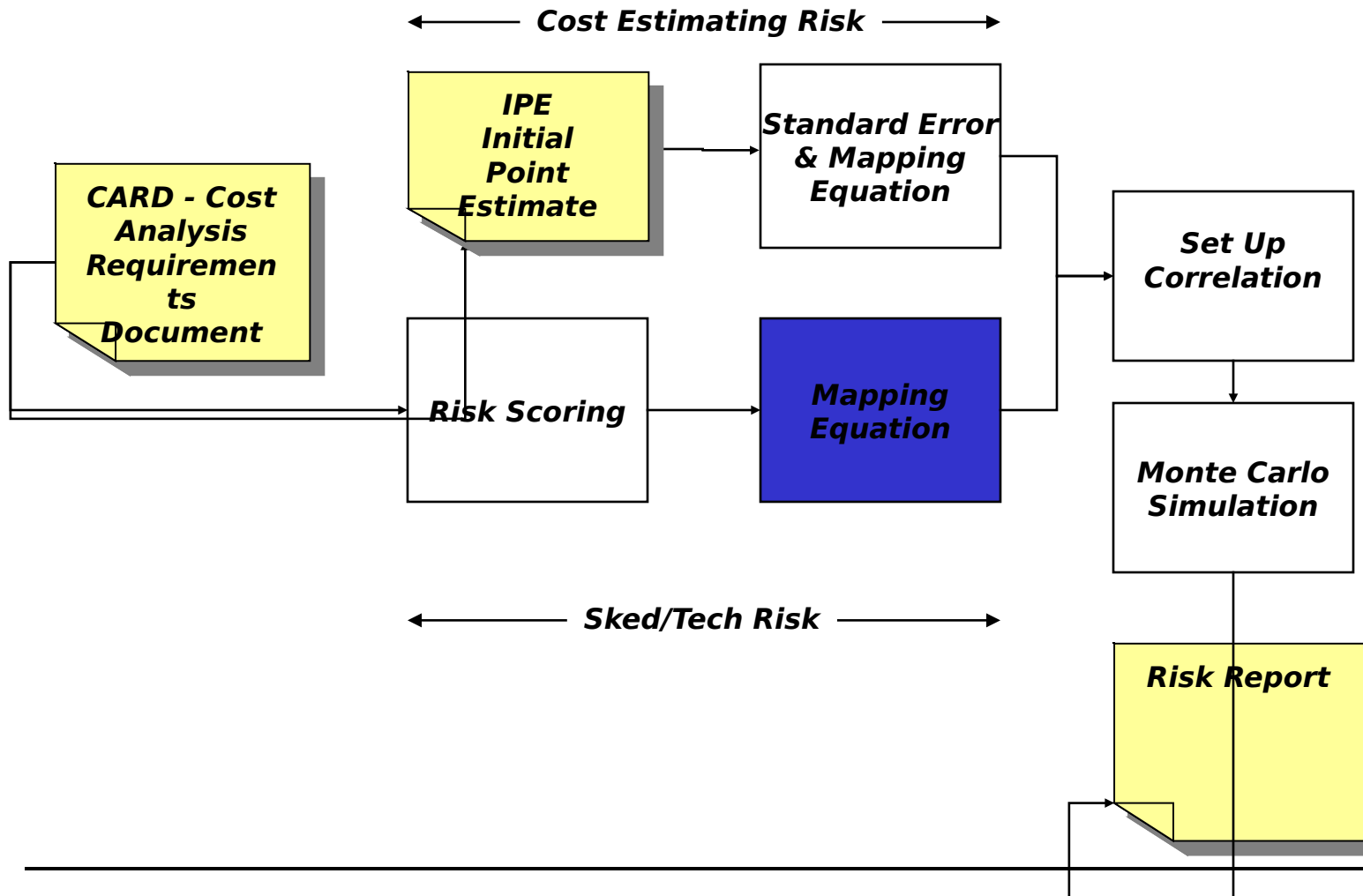
Hardware Risk Scoring Matrix



Risk Categories	Risk Scores (0=Low, 5=Medium, 10=High)				
	0	1-2	3-5	6-8	9-10
1 Technology Advancement	Completed (State of the Art)	Minimum Advancement Required	Modest Advancement Required	Significant Advancement Required	New Technology
2 Engineering Development	Completed (Fully Tested)	Prototype	HW/SW Development	Detailed Design	Concept Defined
3 Reliability	Historically High for Same Item	Historically High on Similar Items	Known Modest Problems	Known Serious Problems	Unknown
4 Producibility	Production & Yield Shown on Same Item	Production & Yield Shown on Similar Items	Production & Yield Feasible	Production Feasible & Yield Problems	No Known Production Experience
5 Alternate Item	Exists or Availability on Other Items Not Important	Exists or Availability of Other Items Somewhat Important	Potential Alternative Under Development	Potential Alternative in Design	Alternative Does Not Exist & is Required
6 Schedule	Easily Achievable	Achievable	Somewhat Challenging	Challenging	Very Challenging



The MDA Cost Risk Process

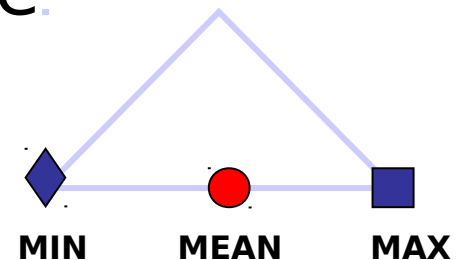




Mapping Risk Scores



- Once we have risk scores we must translate them into cost growth
- We achieve this through a set of mapping equations
- The dependent variable in these equations is the mean of the symmetrical triangular S/T distribution
- The low and high endpoints are derived from the variance of the regression





The Mapping Study



- Used SARs to generate historical cost growth factors (CGF)
- Performed Schedule / Technical scoring on the selected programs
- Ran regressions with CGFs as the dependent variable and risk scores as the independent variable
- Resulting mapping equations used to assess cost growth on current programs



The Mapping Equation



- The Mapping Study produced separate equations for both RDT&E and Procurement

For RDT&E:

$$\text{CGF} = 1 + .057x$$

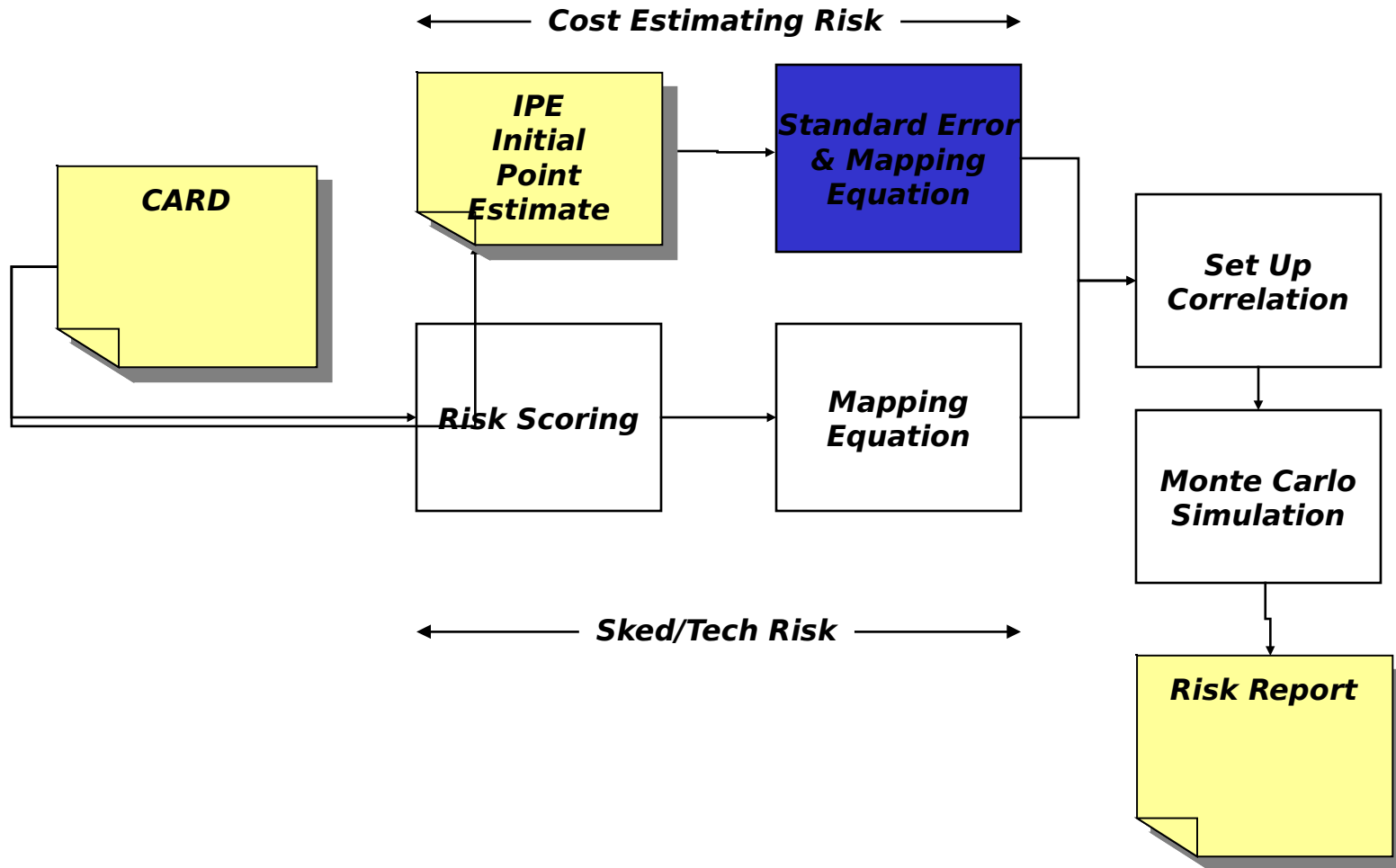
For Procurement:

$$\text{CGF} = 1 + .032x$$

X = Risk Score



The MDA Cost Risk Process





Cost Estimating Risk Assessment



- Cost Estimating Risk is based on two variables
 - The standard error underlying the costing methodology
 - The analyst's confidence in that methodology
- Analyst makes a confidence assessment of the methodology for each WBS item
 - Score of 1 to 5 is assigned, 1 being most confident and 5 being least confident
 - Score is based on the currency and relevancy of the database on which the CERs, analogies, factors, etc. rely

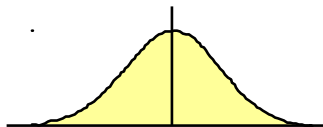


Cost Estimating Risk



RDT&E

Analyst Confidence Score	Mean of Distribution
1	1.055
2	1.071
3	1.087
4	1.103
5	1.119

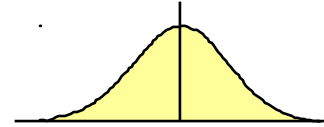


1.087

**Symmetric w/mean
shifted to 1.087**

Production

Analyst Confidence Score	Mean of Distribution
1	1.000
2	1.016
3	1.032
4	1.048
5	1.064

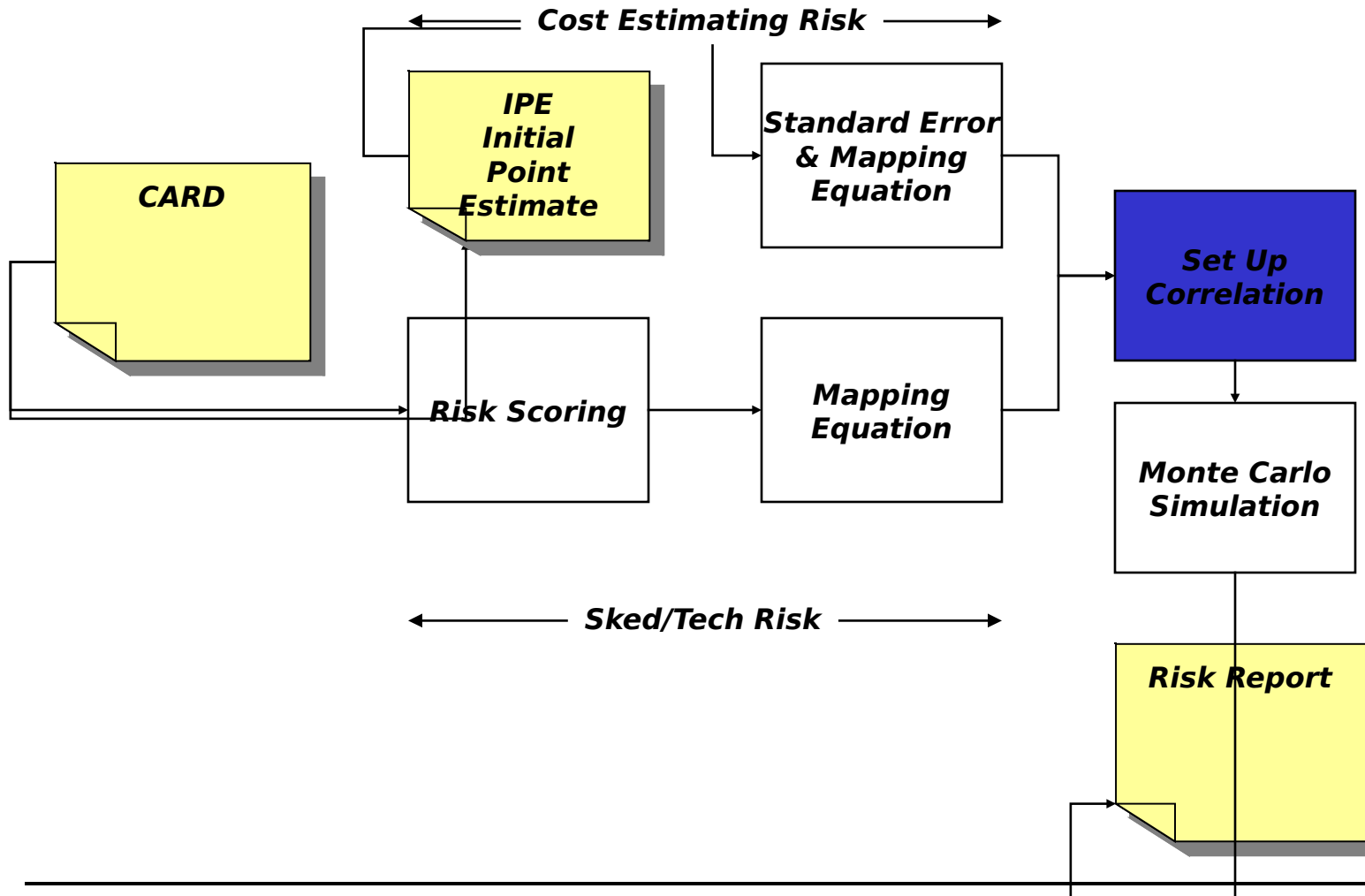


1.032

**Symmetric w/mean
shifted to 1.032**



The MDA Cost Risk Process





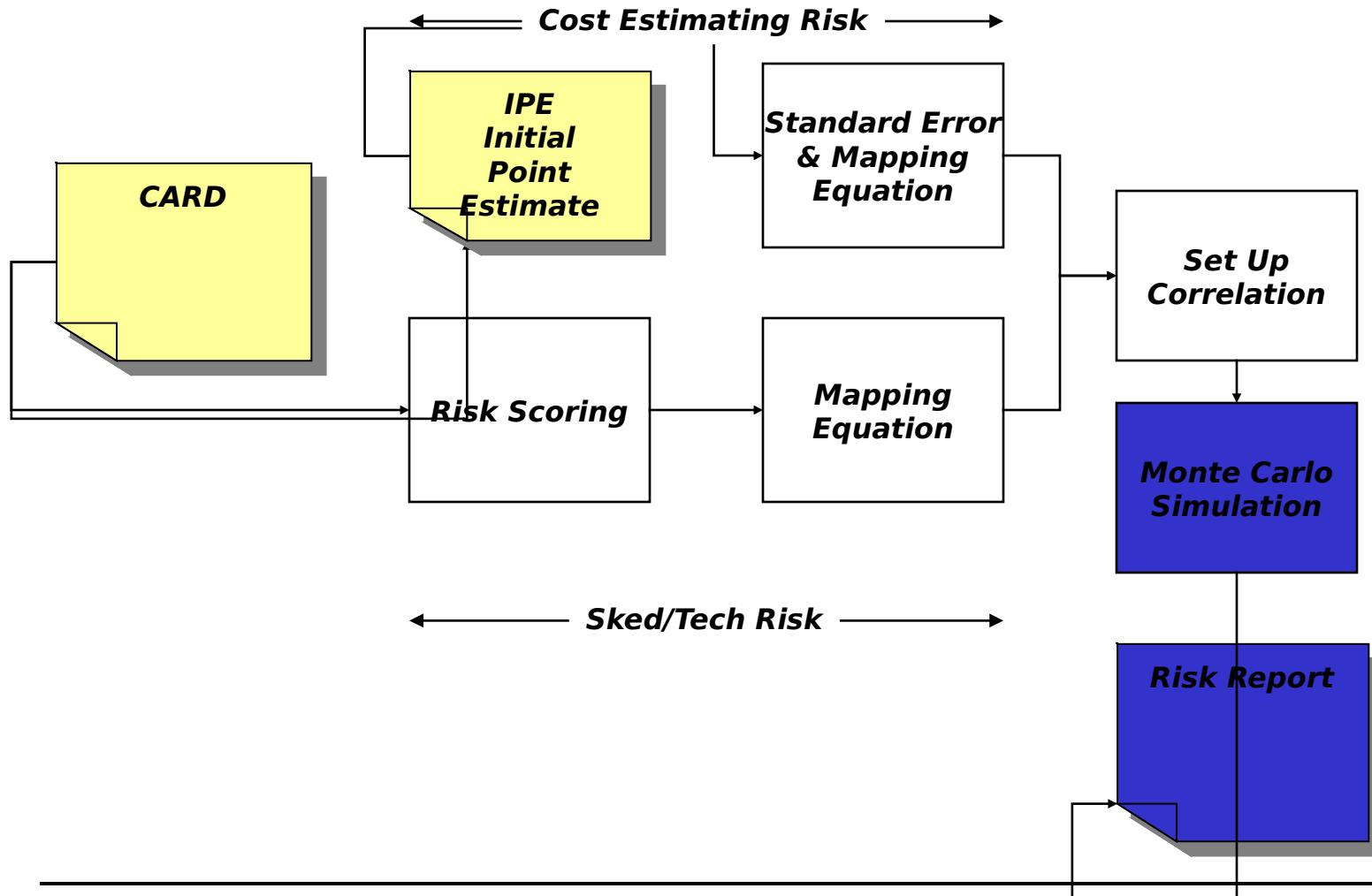
Correlation of Elements



- Correlation is a crucial step in any Monte Carlo simulation
 - Is necessary to produce the correct variance
 - Effectively links the randomly drawn numbers between multiple distributions so that when one is high, so is another, and vice-versa
- MDA models correlation in three ways:
 - Functional Correlation
 - Phase to Phase Functional Correlation
 - Historical Correlation



The MDA Cost Risk Process





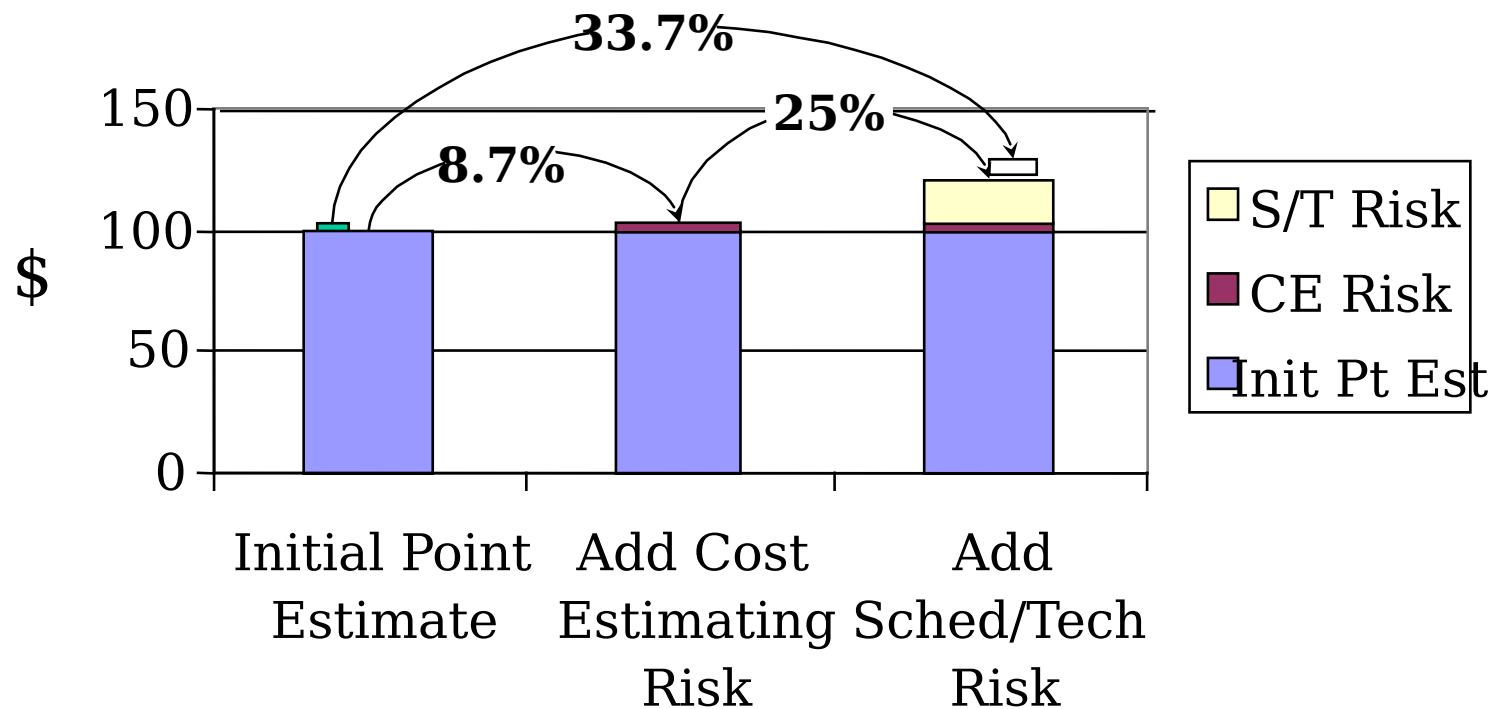
The Monte Carlo Technique



- Set up a CE and S/T distribution for each WBS item
- Set up correlation by linking random draws of correlated elements
- A random draw is made from each of these distributions
 - Cost for each WBS element as well as summary levels are recorded
 - Process is repeated thousands of times to determine range, center, and shape of the resulting cost probability distribution
- We use Monte Carlo because the math of combining all the probability distributions using method of moments becomes quite complex



Example Cost Estimate with Risk – R&D





Risk Report Sample Output

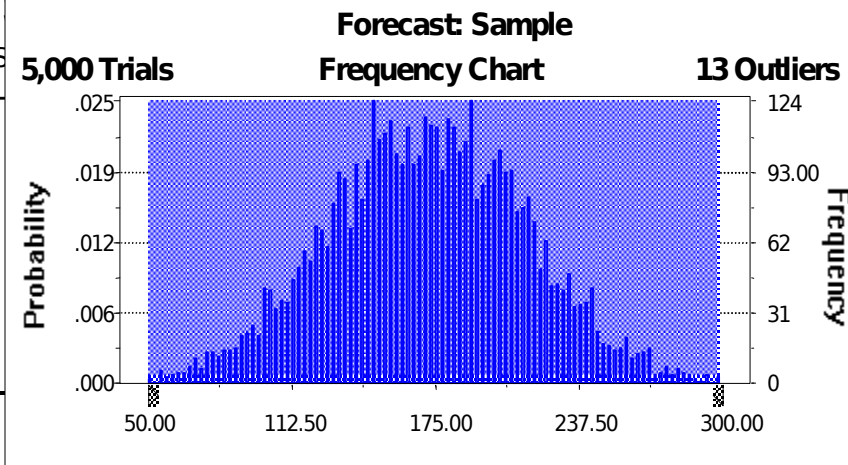


Crystal Ball Report

Simulation started on 1/3/01 at 18:24:18
Simulation stopped on 1/3/01 at 18:24:47

Forecast: MDA Sample Output

Statistics:	Value
Trials	5000
Mean	172.12
Median	172.33
Mode	---
Standard Deviation	43.32
Variance	1877.03
Skewness	0.01
Kurtosis	2.88
Coeff. of Variability	0.25
Range Minimum	22.38
Range Maximum	318.94
Range	6.56
Mean S	0.61





Strong Points



- Historical Basis
- Intuitive / Logical
 - S/T Matrices
 - Produces believable results that are reasonable in relation to historic programs
- Provides Structure
 - Can create a cost risk model within a reasonable effort
 - Provides consistency between programs, if all programs use it
- Produces output that depicts the range, center, and shape of the resulting cost probability distribution



Weaknesses



- Original data is from 1991 and prior
- Used only SAR data
 - Doesn't separate govt. & contractor growth
 - Doesn't give detail breakout of components
 - CCDR data gives more detail
- Max cost growth is limited by linear relationship
- Uses forced intercept (0)
 - S/T of 0 = 0% cost growth
 - Will never predict cost savings even though this occurs in the historic data with a reasonable frequency



Mechanics Report on Current MDA Approach



- Decide on and collect current data
 - SAR, CCDR, etc.
- Decide on scoring matrices
 - SW, HW, IA&T, other ?
 - Score RDTE and Production separately?
 - Determine level to score historic and current programs
 - Determine points in acquisition cycle to score at
- Score relevant projects
- Develop new mapping equations
- Update risk methodology to reflect new mapping equations
- Jump on opportunities to facilitate cost model integration



The Road Ahead

(If We Consider New Methodologies)



- Alternative methodologies
 - Technically based opinion mapped to cost growth history
 - Cost based opinion
 - Probability and consequence
 - Inputs-based risk
 - Residual Characterization
 - Schedule analysis - detailed network (PERT)
- Perform test to see if techniques adequately bound the risk for MDA Programs
- Decide on best methodology
 - Develop methodology
 - Implement methodology



Backup